A Long Range View for the Nuclear Science Community
Future Concepts and perspectives for University-based research and graduate education.

Science Education and Outreach

Oakland Townmeeting, November 2000

B. Balantekin, University of Wisconsin
W. Bauer, Michigan State University
N. Benczer-Koller, Rutgers University
J. A. Cizewski, Rutgers University
B. Clark, Ohio State University
D. Haase, North Carolina State University
K. Kemper, Florida State University
C. Mader, Hope College
R. McKeown, California Institute of Technology
M. McMahan, Lawrence Berkeley National Laboratory
J. Natowitz, Texas A&M
W. Rogers, Westmont College

Contents

1 Charge 2

2 Introduction 2

3 Graduate Education 3

4 Undergraduate Education 8

5 K-12 programs 10

6 Scientific literacy: outreach to society-at-large 12

7 Diversity 13

8 Recommendations 16

1 Charge

In the letter to NSAC asking them to formulate the next long range plan for the nuclear science community, DOE and NSF affirmed the importance of education and outreach in the following paragraph:

Education of young scientists is central to the mission of both agencies and is integral to any vision of the future of the field. We ask NSAC to articulate the importance of education in nuclear science to academia, to medicine, to defense, to industry, and to government. We ask further that NSAC analyze the effectiveness and appropriateness of current graduate programs in nuclear science in preparing future generations of scientists, to articulate the role that the nuclear science research community presently plays in addressing broad educational needs of national concern, including diversity issues, along with strategies for strengthening these roles in a way that makes optimal use of the resources of the community.

2 Introduction

The nuclear science community represents a group of scientists who work in environments that range in scale from national laboratories to small colleges. The community's concern for science and mathematics education should match the national needs for producing a scientifically literate population, and for encouraging and nurturing the next generation of nuclear scientists. Therefore the community should address education at all levels, from kindergarten through post-graduate training, as well as outreach to the general public.

Since the last Long Range Plan in 1995, the number of university laboratories and of "nuclear practitioners" has fallen while the demand for individuals with this knowledge has increased. This increased demand for nuclear scientists is being driven by the many interesting new challenges of the basic science as well as by its many applications in medical and environmental sciences. There is therefore a mismatch between the needs of the field and the input of human capital.

The nuclear science community is actively engaged in a whole gamut of educational activities. Through modern information technology it is now possible to involve many more students in interesting, relevant nuclear science research. Computers have reached the K-12 classrooms and homes, and access to actual research data by these communities has opened new educational opportunities.

Previously the primary educational involvement of the nuclear science community had stressed academic instruction and mentoring the research of undergraduate and graduate students. Increasingly, however, attention has been paid to improve the undergraduate curricula of physics majors as well as the creation of innovative curricula for science majors and non-majors. Many dedicated and imaginative scientists, 60% of those polled, have volunteered their time in efforts to increase the scientific literacy of the public-at-large, and particularly to bring lively science programs into K-12 instruction. These efforts involved direct interactions with teachers and their students in the schools as well as in research laboratories (Fig. 1), preparation of

Figure 1: **Florida State University's Saturday Morning Physics**, a series of lectures for high school students given by members of the FSU Physics Department for the last 15 years. Every Saturday morning in the fall 200 high school students fill the FSU auditorium to explore the frontiers of modern science, including simulating nuclear chain reactions with mouse traps, small wooden pegs and a tennis ball dropped into a fish tank.

materials for web distribution such as the ABC of Nuclear Science, the New Element Discovery, and the History and Technology of Cyclotrons, the creation of the Nuclear Science Wallchart and accompanying Teacher's Guide (Fig. 2), visits to public fora, and production of video-tapes, TV shows and museum exhibits.

In the following sections we will separately look at relevant issues in graduate education, undergraduate education, K-12 programs, improving the science literacy of the general public, and workforce and student diversity issues. We will conclude with a list of recommendations.

3 Graduate Education

The education and training of graduate students is at the core of the education activities in nuclear science since it is these young scientists who will meet the demands for nuclear scientists for basic research and national needs.

The demographics (Fig. 3) describing the population of first year graduate students in physics indicate a decrease in the total population of about 25% since 1990, although the total number appears to have stabilized. The number of US graduate students has decreased by about 50%, but this decrease has been compensated by the inflow of foreign students. The resulting first year student population is equivalent to that of the low numbers of students enrolled at the end of the 1970's. The present dearth of students comes at a time of spectacular achievements in nuclear science and astrophysics: the commissioning of Jefferson Laboratory, the start of operations at RHIC, strong research activities at several university and national lab-

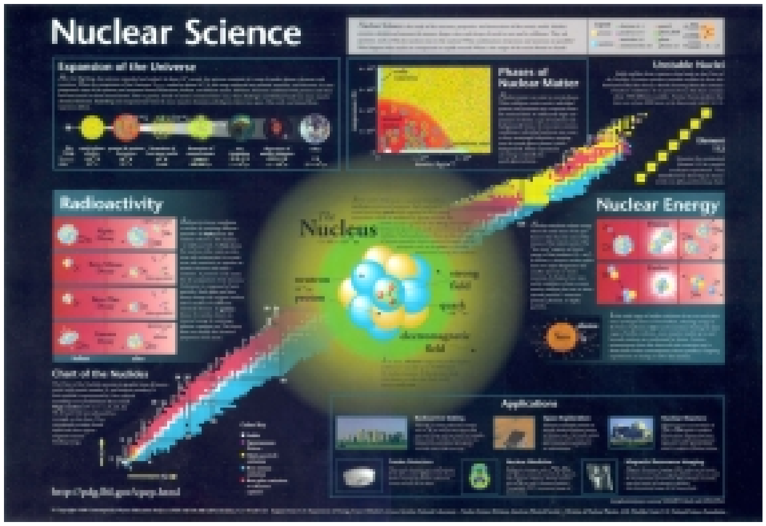

Figure 2: **The Nuclear Science Wallchart:** The Nuclear Science Wallchart was conceived by scientists at LBNL and developed and field tested over a period of several years by a national committee of scientists and teachers. It is published by the Contemporary Physics Education Project, a non-profit organization. URL:`http://www.lbl.gov/abc/wallchart/index.html`

oratory facilities, with concurrent developments of strong user groups, and exciting new opportunities in neutrino physics. This trend in the population of graduate students comes as no surprise, as it is a direct consequence of the significant reduction in the number of physics bachelor degrees compared to the total number of bachelors since about 1985 (Fig. 4). The increase in the number of international students may not meet the manpower requirements for future research activities as well as national needs. Traditionally, a large fraction of international students return to their home country within a few years of the Ph.D. Should they remain in the U.S., international students may not meet all of the national needs for nuclear scientists (for example in defense) until they become citizens, assuming they continue to be interested in such careers.

The universities, and in particular, the nuclear laboratories at universities, provide the fundamental education and training of the next generation of nuclear scientists. It is at the universities that future nuclear scientists are identified, educated in the basics of the field, and mentored in their development. It is also at universities that young nuclear scientists are exposed to broad areas of science other than physics or chemistry, through formal studies and intellectual ferment. This exposure is critical to enable future scientists to meet the needs of the full spectrum of national activities in basic and applied science.

Traditionally, the focus of training of experimental graduate students in the techniques and science of our field was provided by the university-based nuclear laboratories. These facilities, although shrinking in number, continue to play a vital role in the education of the next generation of nuclear scientists. At university laboratories the graduate students are exposed to and participate in the complete spectrum of

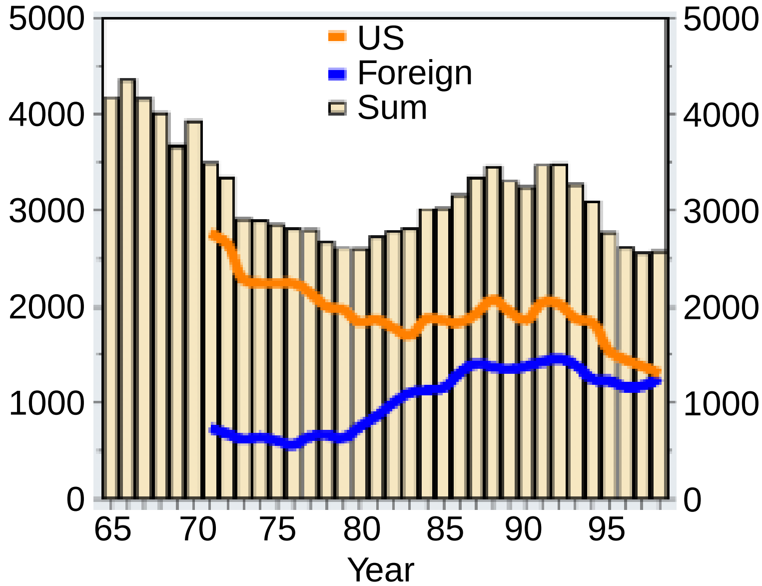

Figure 3: Demographics of first year physics and astronomy graduate students, comparing US to foreign nationals. Source: AIP 1998 Graduate Student Report.

activities in experimental science. They typically play an active role in the design, construction, calibration, and/or maintenance of apparatus, in addition, to exploiting these instruments for research. In addition they are actively involved in the data taking, analysis, and interpretation of results. Given the smaller scale of projects at university labs, and the less restrictive time constraints, the students can develop into true experimentalists, poised to become leaders in the field, with a breadth of technical skills, and experience in being part of a team. In addition, the intellectual atmosphere of a university can provide ongoing exposure to the full breadth of activities in physics or chemistry, as well as applied areas of research. The university laboratories are also particularly cost-effective due to university contributions and generally lower overhead costs. Given the forefront research conducted at university laboratories, as well as the unique role they play in educating and training young nuclear scientists, the funding agencies should enhance the support for the remaining facilities and sustain that level for the future.

For several decades experimental nuclear physicists have been conducting an increasing fraction of their research at large centralized facilities, and this trend is expected to continue in the 21st century. There are today five major national laboratories and facilities (Argonne National Laboratory, Brookhaven National Laboratory, Jefferson Lab, Lawrence Berkeley National Laboratory, and Oak Ridge National Laboratory), but only ten university laboratories (Florida State University, University of Kentucky, Massachusetts Institute of Technology, Michigan State University, University of Notre Dame, Ohio State University, State University of New York at Stony Brook, Texas A & M University, University of Washington, and Yale) available for research training of graduate students. As a result, the role of university groups and

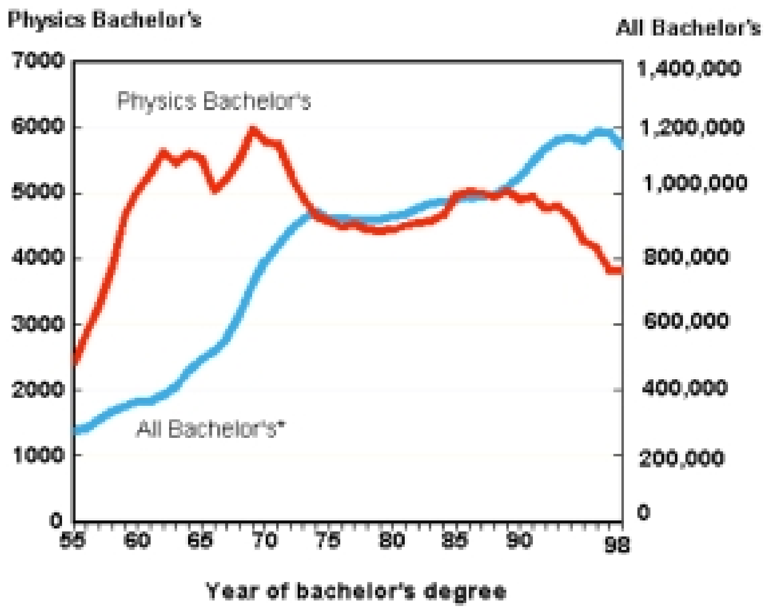

Figure 4: Trends in undergraduate enrollments in physics compared to the overall enrollment.

the style of graduate student training in experimental nuclear physics research has been undergoing significant change. Graduate students often begin their careers at the university, taking courses and gradually shifting their activities to experimental research at one of the large facilities. The adoption of this pattern increases the importance of providing opportunities for graduate students to be involved in all aspects of experimental research. This educational opportunity should include designing, constructing, commissioning and implementing experimental equipment in an atmosphere that addresses the needs of the student. In this regard, the existence of appropriate facilities for development of modern state-of-the-art hardware for nuclear physics research at the universities is essential. This capability must include the availability of modern test and measurement equipment, technical staff, and research staff at the university. Therefore, the tendency to concentrate resources at the large facilities (generally located at national laboratories) must be coordinated with a conscious and deliberate policy to maintain strong capabilities in the university groups. This policy is essential to insure an appropriate high-quality education for the future leaders of the field of nuclear physics.

Another important aspect of a graduate student's experience at the university is the exposure to intellectual discourse in the current topics in nuclear physics and related fields. Ideally, students should have the opportunity for informal interactions with theorists as well as experimentalists. Wherever possibly, support for quality theory programs associated with strong experimental groups should be encouraged. This type of arrangement provides an atmosphere where students can achieve a well-rounded educational experience in the field of nuclear physics and also generates opportunities for enhancing theoretical work in the field.

In addition, there are structural differences between the training of students in experimental and theoretical areas. In experimental areas nowadays most groups work in relatively large collaborations, whereas in most universities, nuclear theory groups tend to be small. The small size of the nuclear theory groups may be detrimental to the training of young people as it leads to isolation, limits interactions with the adviser and does not provide a diverse spectrum of ideas and styles of doing physics. In contrast, experimental students in collaborations, work closely with students, post-doctoral fellows, and faculty from other universities and are exposed to the diversity of nuclear physics.

The community has taken a number of steps to remedy this situation. The National Nuclear Physics Summer School and more specialized summer schools organized by Jefferson Lab and Brookhaven National Lab have been very useful in this regard. In these schools students meet not only each other–their future colleagues–, but they also get to know the leaders of the field who lecture them. The summer schools were deemed to be very effective by all people involved as they fill a very important gap in the education of students and particularly of the theory students. In addition, the National Nuclear Physics Summer School allows students from different areas of nuclear physics to recognize that they are part of a larger community.

The nuclear physics community has also been rather successful in mentoring its graduate students. For example, it is common for the nuclear physics students to give ten minute talks at the APS meetings, a practice not widely accepted in other sub-fields of physics. Another example is provided by the approach used by the National Institute of Nuclear Theory (INT) to interact with students. INT not only accepts students to its regular programs, but also treats them as equals to other participants. Over the years many students who attended the INT programs found them most effective for their research as well as their general education. Funding agencies should be encouraged to continue providing funding for these beneficial activities.

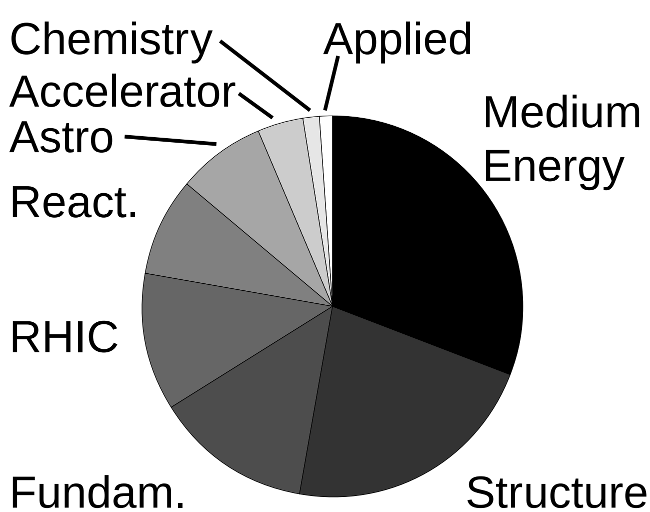

Figure 5: Distribution of the sub-fields in which Ph.D.'s have been awarded in nuclear science in the years 1994 to 2000.

The sub-fields of nuclear physics in which Ph.D.'s have been awarded during the period 1994-2000 are displayed in Fig. 5.

Nuclear Chemistry continues to be an important aspect of nuclear science, not only because of the basic frontier research (such as chemistry of the heaviest elements), but probably more importantly for its impact on national needs, such as nuclear medicine and radiobiology, radiopharmaceutical chemistry, and nuclear waste disposal. There has been a dramatic decline in the number of departments offering degrees in nuclear chemistry, and consequently in the number of undergraduate majors and Ph.D.'s.

4 Undergraduate Education

To meet the national need for nuclear scientists and a citizenry with a strong scientific background, the community must nurture its undergraduates by providing opportunities for research and networking with their future colleagues. This goal must be achieved before all the bright youngsters are swept off into the software industry and other competing fields of current interest and social impact, such as ecology, the environment, oceanography, meteorology...

Research has proved to be a strong enticement for students to consider pursuing a career in science. University nuclear science groups and facilities routinely involve bright and eager undergraduate students in their activities, often starting in the freshman year. These students learn modern research techniques and frequently make significant contributions to the research program. A very large proportion of these students go on to graduate school. But a large percentage of our future nuclear scientists attend small colleges which do not have on-going research programs. These students may not experience real research unless they enroll in summer programs on larger campuses or laboratories. The community has taken advantage and greatly benefitedœ[Dœ[Dœ[Dœ[Dœ[from the NSF programs such as Research at Undergraduate Institutions (RUI) and Research Experience for Undergraduates (REU) as well as the Energy Research Undergraduate Laboratory Fellowship (ERULF), a DOE program.

The RUI program has had a direct impact on faculty at undergraduate institutions, enabling them to maintain active research programs and to remain connected with the larger professional community. In turn research activities provide intellectual stimulation and invigorate the professor in the classroom, in addition to engaging the students directly during the summer as well as during the school year. Such an early exposure to on-going science has proven to increase students' overall acceptance and understanding of scientific issues. A common challenge at undergraduate institutions is isolation from the larger scientific community. While working closely with their own students is important, equally essential is the communication and collaboration with other scientists which is vital to participation at the cutting edge of science. This connection grants these groups more direct access to facilities and equipment not available in the typical undergraduate institution. At Hope College, for example, the nuclear physics group consists of three experimental and one theoretical physicists. All the students are part of the group, participate in collaboration meetings, are active, hands-on, players in the actual experiments at university and national laboratories and take a lead in data analysis and modeling.

A new program, Conference Experience for Undergraduates (CEU) conceived and administered by faculty at Westmont College with support from the APS Division of Nuclear Physics, the NSF and the DOE through National Laboratories, has had a spectacular success. This program has been extremely successful in integrating into the nuclear science community undergraduates from non-research institutions who are doing research during the summer in host laboratories. The students are supported to attend and present the results of their experiments at the Fall meeting of the Division of Nuclear Physics (Fig. 6). Their work is highlighted and praised, and the students emerge from this experience with the feeling of having become full participants of the research establishment. Specific benefits gained from the CEU program over the last three years include the following:

Figure 6: The CEU was established in 1998 with the help of Westmont College faculty and the support of DOE and NSF as well as many individual institutions who provided travel funds. A total 200 undergraduates have attended and presented posters at the DNP Fall Meetings in Santa Fe, Asilomar and Williamsburg.

- The participating students discover that professional nuclear scientists are genuinely interested in their individual accomplishments, and that their work is truly relevant to the field as a whole.
- Students meet one another and derive encouragement and support from peers who share a common interest and bond in physics; they catch a vision of their own possible future in nuclear science, meeting potential colleagues and collaborators.
- Students see the human face of the scientific enterprise, and learn first hand

Table 1: Demographics of the CEU program

Year	#Students	%Women	% Minority
1998	60	30	NA
1999	60	40	NA
2000	80	25	5

how fundamental communication and sharing of ideas and information occurs among professional scientists.

- Students talk with various graduate institutions' representatives and discuss future prospects for graduate school and research. Discussions with the participants show that many students might not have considered graduate school had they not been exposed to real interactions with research scientists.

The DNP community benefits greatly from the presence of bright young scientists at the meeting. Numerous colleagues have expressed sincere appreciation for the energy and enthusiasm the students bring to the meeting, and many have suggested that meeting the students and attending the undergraduate poster session is one of the highlights of the meeting. Table 1 shows the level of participation of students in this program over the last three years.

The Division of Nuclear Chemistry and Technology, in partnership with DOE, has also supported two summer school programs at San Jose State University and Brookhaven National Laboratory, designed to encourage students to pursue careers in nuclear science. Twelve students participate yearly in each of these programs.

The community reaffirms the importance of the REU, RUI, CEU and Summer programs. It encourages its members to play an active role in these programs, to encourage students to participate in the broader-based interdisciplinary undergraduate research conferences held on many individual campuses and at the Annual Fall meeting of the DNP. The continued federal funding of these programs, of *new* initiatives, and of research partnerships at the smaller university-based laboratories and undergraduate institutions is a key to their success.

5 K-12 programs

The K-12 school population is a fertile field where the introduction of the exciting activities of nuclear science can make a large impact on the innate curiosity of children for the world around them. The Division of Nuclear Physics of the American Physical Society has recognized this pressing concern and has established a Committee on Education charged with supporting educational programs, developing new initiatives and creating materials for mass media dissemination of scientific accomplishments. This Committee can become a major resource for the educational thrusts of the community.

The national laboratories and some university facilities have the scale and expertise to maintain extensive K-12 outreach programs which include student enrichment programs, teacher training, curriculum development and public science-awareness outreach.

Because of their scale, the large laboratories can make good use of education professionals to translate the science of the laboratories to the K-12 arena in ways that support and enhance K-12 education. However, in order for this to be effective, these programs need the direct support of dedicated research scientists to act as mentors, so that teachers will begin to feel comfortable around scientists. Only when they realize that scientists are human and can make mistakes, and that scientific research is not constant progress but has setbacks and pitfalls just as in a high school chemistry laboratory, will they be able to engage in meaningful dialogue.

At one time the Department of Energy provided separate funding for laboratory outreach offices, but through mandates of Congress, budget reductions over the past six years have dramatically reduced the level of effort. The community strongly supports re-establishment of the education outreach offices at the national laboratories, and encourages increased and sustained funding for educational partnerships at the smaller university-based laboratories. The downward trend in education funding at DOE has been reversed for FY01, with the new DOE budget providing \$4.5M for education to the Office of Science. The community needs to be vocal to ensure that this funding is retained in future years.

The nuclear science community can and has produced quality curriculum materials for the use of K-12 teachers. Developing materials is only the first step, however. Teachers have to be made aware that it is available and feel comfortable using it. Since only about one third of physics teachers in the US have had an undergraduate major or minor in physics, this approach may present a major impediment. However, many individual scientists have productively participated in such curriculum enhancement programs in their local communities. New curricular materials must fit within the framework of the National Science Standards and local implementations of those standards. New materials should reflect both new advances in physics knowledge and the changes in how scientific investigation is carried out. The preoccupation of the standard curricula with classical physics only prepares students to work in 19th century laboratories. Modern physics topics should be included to prepare students to analyze 21st century problems such as environmental issues and nuclear waste of power generation.

The nuclear science community needs to work closely with related physics disciplines and the American Association of Physics Teachers (AAPT) to develop and market such curriculum material. Recent efforts in Physics Education reform,such as the NSF-sponsored University Preparatory Program (UPP) and the Course Curriculum Laboratory Improvement (CCLI) funding initiatives have indeed led to the development of new materials, mostly aimed at introductory physics courses. The newly developed materials must be publicized and made available to the community. Active involvement by the APS-DNP and ACS-DNCT in reporting and encouraging these developments would help increase community awareness and enhance the coverage of modern physics in the classroom. As example of a well disseminated effort, the Nuclear Physics Wallchart and accompanying Teacher's guide were developed and marketed through the Contemporary Physics Education Project (CPEP), a non-profit organization of physicists and educators. Pooling resources with other fields of modern physics is important to develop the critical mass necessary to accomplish change.

The community can expand its impact on K-12 education using a variety of approaches:

- The DOE should be encouraged to follow the lead of NSF and NASA in requiring an educational component in proposals for all major research projects.

- Working with high school teachers and schools to improve the quality and relevance of science teaching, in all areas of science. Some of these changes will occur through nuclear scientists bringing ideas and apparatus into classrooms, or through workshops. Some will occur by partnerships with other scientists and educators designed to develop general science improvement strategies, support more student science programs, or by work with Physics Alliances. There are too few future scientists in all disciplines and the entire student pipeline must be enlarged, not only nuclear science.

- The nuclear science community, through the lead of the DNP Education Committee, needs to consider a major education/outreach proposal to the NSF, following the lead of the project QuarkNET in the HEP community. This project is unique in that it is funded by NSF but is based at the DOE laboratories. It would be necessary to develop a broad theme which would encompass a large component of the community and would also fire up the imagination of teachers and students. A few areas of high visibility and interest would involve, for example, projects related to neutrino interactions at SNO or nuclear spectra data from large arrays such as Gammasphere.

Many scientists and educators support K-12 education by speaking out on local and state educational issues. There is a continuing need for scientists to work to increase the quality of K-12 mathematics and science programs. The community has contributed to this goal through involvement in PTA's, attendance at school board meetings, participation in state curriculum development forums and by serving as consultants to local and state systems. The community has mobilized several times in the recent past to defend the science funding in Congress. It should also mobilize to defend science in schools. In this spirit, the APS/DNP has created a Public Information Committee charged tocommunicate the exciting developments in nuclear science to the agencies, members of Congress, the press and the public.

6 Scientific literacy: outreach to society-at-large

The technological developments of the future will require an increasingly literate citizenry. While most efforts in the nuclear science community have been directed towards students in public schools, colleges and universities, several thrusts toward enhancing the scientific literacy of the public-at-large have been carried out by the national laboratories, major university laboratories and many individuals either working alone or participating in large scale state wide interdisciplinary science outreach programs. These activities include a remarkable variety events ranging from teaching at various levels to school children and their teachers, summer programs, Saturday Morning Physics, open houses, the BEAMS (Becoming Enthusiastic About Math and Science) program at Jefferson Laboratory, the Science House at North Carolina State University, computer-based outreach initiatives such as the Washington Area Large Timing Array (WALTA), the California High School Cosmic Ray Observatory (CHICOS), inviting the public to viewing nights at university telescope facilities, judging at science fairs, running Physics and Science Olympiads, and entertaining educational activities like the Flying Circus of Physics, Physics is Phun, the Science Theatre, to discussions with the media, creation of exhibits and publications explaining and popularizing science.

As a specific example of one of these initiatives, CHICOS is a collaborative project involving CalTech, California State Northridge, UC Irvine, and local high school physics teachers to site an array of particle detectors at high schools in the Los Angeles area. Ultimately, this array will be capable of detecting and characterizing the very highest energy elementary particles ever observed. The project will offer students in local high schools a unique opportunity to collaborate with researchers at CalTech and UC Irvine and address fundamental issues at the forefront of present-day astrophysics and particle physics. Thus, in addition to establishing a state-of-the-art experimental facility for high-energy cosmic ray studies this project will provide an exceptional educational experience for high school students in the Los Angeles area. Curriculum materials including evaluations, associated courses at California State Northridge and summer workshops at CalTech will contribute to the training and educational experience for the teachers. These activities will in addition include participation of CalTech, UC Irvine and California State Northridge undergraduates.

Another example of successful community outreach is provided by the creation of a regional science museum for children in Indiana where funding for a new building is actively being sought by nuclear scientists at the University.

The main problem with most of these activities is that only a relatively narrow group is aware of them. Thus these activities should be publicized and made available to the community via a repository of materials, accessible to all, and should be further abetted by appropriate encouragement from the funding agencies and university administrations. Such a repository will collect, in one location, all outreach, K-12, undergraduate and graduate activities as well as lists of potential speakers. This is one of the main projects the DNP education committee is currently working on. An example of how the web-interface and the printout version of the "education/outreach" database might look is displayed in Fig. 7.

7 Diversity

In spite of considerable efforts, women and minorities are not yet adequately represented in the nuclear science community. In the future, the human profile of the

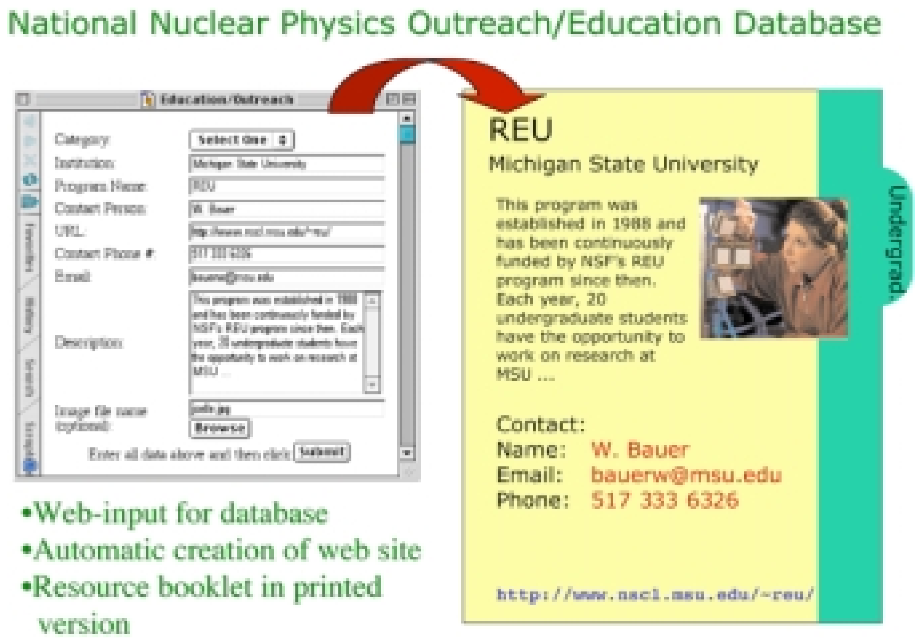

Figure 7: Proposed education and outreach database project for the nuclear science community. For more information, please send an email to `NucOutreach@pa.msu.edu`.

community is likely to change dramatically, but mainly through the large influx of foreign students. In 1998, 13% of the awarded Ph.D.'s were earned by women and minorities and 46% by foreign citizens. Fig. 8 show the breakdown of undergraduates, graduate students and postdoctoral fellows working with DOE and NSF Principal Investigators since 1994 as polled in the recent DNP poll.

While the number of women in the profession has grown slightly since the last Long Range Plan, the number of US minorities, especially African Americans has not. Several scientists have specifically focussed on recruiting inner city students into a variety of undergraduate programs such as the REU program at the University of Pittsburgh, special outreach to college-bound African-American students at Notre Dame and Carnegie Mellon University, the University Preparatory Program at California State University, the Mellon Minority Undergraduate Fellowship Program (MMUF). Another example of a particular activity aimed at increasing the diversity in the field is provided by the efforts carried out at the Seaborg Center at Los Alamos to bring nuclear science education into the schools of the Navajo Nation.

The DNP has, for a number of years, had functions at their fall meeting sponsored by the The American Physical Society's Committee on Minorities (COM) and the Committee on the Status of Women in Physics (CSWP). For example, at the Fall 2000 DNP meeting they jointly organized a lunch reception for the DNP members and the CEU students. Funding for the luncheon was provided by a generous grant from Southeastern Universities Research Association (SURA). Over 80 people attended the luncheon and the organizers were very pleased that a large number of the CEU students took the opportunity to meet with and ask questions of the physicists at the

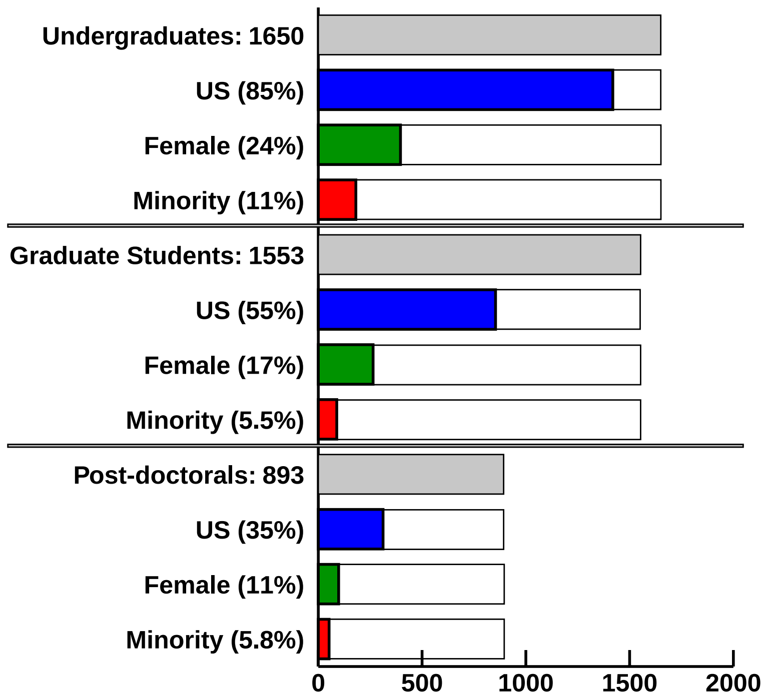

Figure 8: Profile of 1650 undergraduate students, 1553 graduate students, and 893 postdoctoral fellows working with NSF and DOE Principal Investigators since 1994.

lunch.

During the lunch the highlights of COM and CSWP programs were discussed. These programs help the individual laboratories or research groups identify minority and women candidates. Both COM and CSWP maintain colloquium speakers lists which can be used to identify women and minority speakers. These activities benefit from a corresponding Travel Grant Program, which provides travel reimbursement of up to $500 to departments that invite women and minority speakers to give department colloquia or seminars. Both committees sponsor site visits in which a committee will, when invited, visit physics departments and national laboratories and work with them to develop a welcoming climate for all students and faculty, particularly underrepresented groups.

In spite of these very worthy attempts, the number of training and nurturing programs aimed at attracting minorities and women to scientific careers remains very small. These activities must be strengthened and vigorously pursued.

8 Recommendations

- **University-based research groups and laboratories are the lifeblood of our field.**

  The federal investment in the university infrastructure has traditionally been a major source of funding for science education. Continued federal support with appropriate matching from State and educational institutions is essential to take full advantage of the opportunities to immerse young scientists into frontier scientific environments and to train future generations of nuclear scientists for basic research and national needs.

- **Science education and literacy are critical to the future of the nation.**

  Education and outreach activities to K-12 and society-at-large need to constitute a strong component of all new major institutional research proposals. Educational institutions in partnership with Federal funding agencies need to identify additional resources for these essential activities.

  The community should consider the establishment of an "Educational Fellowship", modeled after the APS "Congressional Fellowship"program, to be supported by APS/DNP and other Federal funds. This program would be designed to encourage and support interested scientists to develop new educational initiatives at all levels.

- **The social diversity in the nation should be reflected in its scientific force.**

  Efforts to recruit, train and retain underrepresented elements of the work force into the study of science must be increased at all levels of education, research and funding.